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WEARING QUALITIES OF TIRE TREADS AS INFLUENCED BY RECLAIMED RUBBER

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ABSTRACT

Service tests were made on 80 "sectional tread" tires in order to determine the comparative resistance to wear of tread compounds containing reclaimed rubber and those compounded using new rubber only. The tread of each tire was made in four sections, each section representing a compound under test. The results of tread wear as obtained from each individual tire are shown, and, for comparison, data on laboratory wear tests of the same rubber compounds are also given. These results show that the substitution of reclaimed rubber for new rubber in these compounds reduces the resistance of the compounds to wear roughly in proportion to the amount of reclaimed rubber used.

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I. PURPOSE

The question is often raised, especially at times when the cost of crude rubber is high, as to whether an economic gain would result from the greater use of reclaimed rubber in tires. Consequently an investigation was carried out in which tests were conducted for the purpose of determining the influence of reclaimed rubber on the resistance to wear of tire treads, and to obtain data on the relative wear of tread compounds, which could be used for comparison with the same compounds tested on laboratory wear testing machines.

II. DESCRIPTION OF ROAD TESTS

Eighty 30 by 3½ cord tires of standard 4-ply construction were used. The tread of each tire consisted of four sections, each section covering one-fourth of a tire circumference so that as the tread wore away the comparative resistance to wear of the four compounds could be determined from a tire with the knowledge that all parts of the

tread had been subjected to the same load, road conditions, etc. Of the 80 tires, 40 were made by each of two manufacturers and are designated in this paper as No. 1 and No. 2 tires, respectively.

In deciding upon the particular compounds to use in these tires, the proposition was presented to two of the largest tire manufacturers in the country and it was left to their judgment to properly balance the recipes so as to obtain as good a tread compound as possible with the particular reclaimed rubber content.

The compounds have been designated as follows 1A, 1B, 1C, and 1D for the type 1 tires and 2A, 2B, 2C, and 2D for the type 2 tires. The compositions of the No. 1 tread compounds are as shown in the following table:

	Compounds, per cent by weight			
	1A	1B	1C	1D
Smoked sheet	61.1	51.30	45.925	41.175
Hexa[1]	.4	.45	.450	.450
Sulphur	3.0	3.00	3.000	3.000
Zinc oxide	12.5	11.25	8.625	6.375
Gas black	16.0	16.00	16.000	16.000
Mineral rubber	5.0	5.00	5.000	5.000
Palm oil	2.0	3.00	3.000	3.000
Reclaimed rubber	.0	10.00	18.000	25.000

[1] Hexamethylene-tetramine.

In the No. 2 compounds reclaimed rubber was used in a similar manner: 2A contains no reclaimed rubber; 2B, 10 per cent; 2C, 20 per cent; and 2D, 25 per cent of reclaimed rubber. The manufacturer who furnished the recipe, however, did not wish it published.

The tires were run on automobiles which traveled over the roads of the District of Columbia, Virginia, Maryland, and Delaware. A large number of them were used on the cars of rural delivery mail carriers which ran over definite routes each day so that it was possible to note whether different types of roads influenced the relative wear of the different tread sections.

Each tire was run at least until there was sufficient tread wear to give a good comparison between the different sections, and in most cases the test was continued until the poorest section had worn practically through to the breaker. This required generally about 7,000 miles, although on some roads tires ran as high as 14,000 miles before the tread was worn through. When the road tests had been completed the tread was stripped from each tire and a sample 10 inches long cut from the center of each of the four sections to be used as a basis for calculating the relative tread wear. As the original length of each section was approximately 24 inches, this eliminated the parts of the tread within 6 inches of a joint. In considering a means for determining the wear of the different sections, three methods

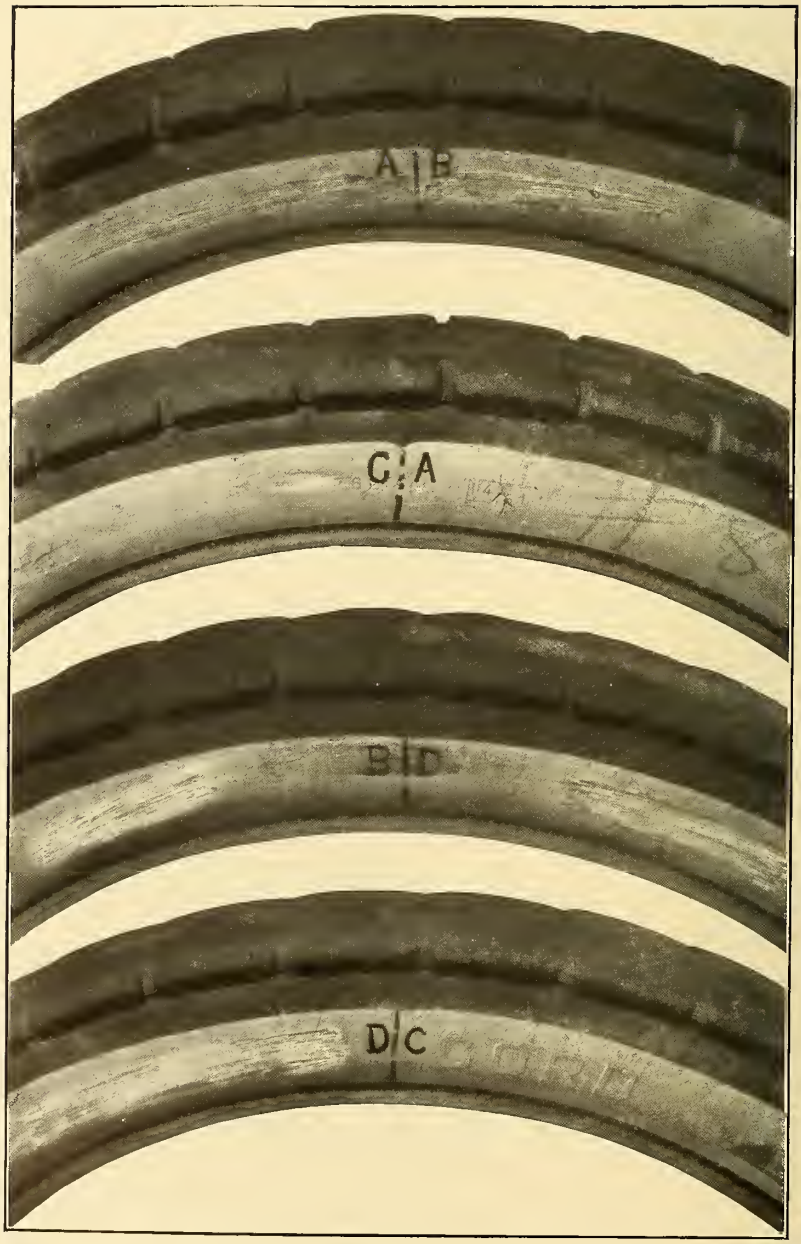

FIG. 1.—*Typical conditions of tires after the road tests*

were tried: (1) Using the complete 10-inch section of tread and calculating the volume of rubber worn away, based on the loss in weight and the specific gravity. (2) Using a central three-fourths inch strip only from each 10-inch section and calculating the volume of rubber worn away, based on the loss weight as in (1). The tread design of both types of tires was such that this eliminated the "non-skid" portion and gave a strip ¾ inch by 10 inches of practically uniform thickness. (3) Using the ¾ by 10 inch strip as in (2) and basing the resistance to wear of the different sections on the loss in thickness as determined by measurements of strips from used and unused treads.

The first method was discarded, as the wear on the edges of the treads was in most cases much less than in the center, and the results, though in the same order of magnitude, were not as consistent as when the center only was used.

The second and third methods should give identical results, but due to difficulties in cutting the strips accurately the third method proved preferable and accordingly was used.

An examination of several of the unused tires which were cut in connection with other laboratory determinations showed that the tread thickness was fairly uniform throughout individual tires and throughout the lots. Accordingly, an average value for the original tread thickness was determined for each type of tire and used for all the tires of that type.

The relative resistances to wear of the compounds in each tire have been calculated from the loss in tread thickness and are based on the assumption that the resistance to wear is inversely proportional to this loss.

The index [1] of the resistance to wear has been calculated for each compound, based on a value of 100 for the "A" compound in each tire as an arbitrary standard. Those compounds with less resistance to wear than "A" have an index less than 100 and those with a greater resistance to wear have an index greater than 100.

III. RESULTS OF ROAD TESTS

Figure 1 shows the typical conditions of the tires after the road tests. It will be noted that the difference in the tread wear on the different sections is very pronounced, and that the "A" section shows up very plainly as being superior to the other three in its resistance to road wear.

[1] The index of resistance to wear is a number expressing the relative resistance to wear of a compound compared with that of a standard compound. It is proportional to the time required to wear off a unit volume of the test compound divided by the time required to wear off a unit volume of the standard compound. Thus, the better the compound resists wear the higher this index.

Of the 80 tires tested 23 were disregarded, as their condition after the road test was such that it was not possible to obtain reliable figures on the comparative tread wear of the different sections. In some cases, also, it was not possible to obtain a numerical relation between all the sections. In such cases only the "A," "B," and "C" or the "A" and "B" values were calculated. The reasons for eliminating these tires or sections were various. Several were damaged by cuts before the tire had run a sufficient distance; some had been abraded so badly from running in ruts that the markings of the different sections were obliterated; several were worn to such an extent that the breaker and carcass had taken part of the wear; and others were worn in spots, apparently due to the sudden application of brakes. In the majority of these cases, however, it was evident from inspection that the "A" compound was superior to the other three and that had it been possible to obtain a numerical relation between the different compounds, the results would have been in line with the conclusions which have been drawn.

In Figures 2 and 3 the results of the road tests are shown. Each line starting with the "A" compound as 100 represents one tire. Front and rear wheel values are shown separately in the top and central groups of curves, respectively, and the averages in the bottom group. The different types of roads over which a tire was run are also indicated wherever such a classification was possible.

IV. COMPARISON OF ROAD TESTS WITH LABORATORY TESTS.

In order to determine whether the same relative resistance to wear of the various compounds as shown by road tests could be indicated by laboratory methods, sheets of each compound were made with a cure equivalent to that of the tire treads. These sheets were tested on laboratory wear machines, the operations of which are briefly described as follows (see also fig. 4):

Machine G.—Samples 1 inch square and one-fourth inch thick are secured to a weighted arm and pressed against the face of an abrasive wheel 6 inches in diameter, which is surfaced with garnet paper.[2]

Machine H.[3]—Twelve samples each 2 by 3½ inches by ¼ inch are fastened around the circumference of a flat-faced wheel approxi-

[2] In making these tests the conditions were varied to determine the influence of (1) the load on the sample, (2) the grade or size of abrasive particles on the garnet paper, and (3) the speed of the abrasive wheel. The same relative results were obtained with loads of 4, 6, and 8 lbs./in.², but the lightest load is considered best suited for this test since there is less tendency for the sample to vibrate. The four grades of garnet paper tried, namely, grades 0, 1½, 2½, and 3½, gave very similar results. Grade 2½ cut the fastest in practically all cases, and from that standpoint is preferable. The results plotted in figures 4 and 5 represent average data as obtained from the three loads and the four grades of garnet paper, and a speed of 30 revolutions per minute. Of the various speeds tried, 30 revolutions per minute proved the most satisfactory as with higher speeds there was a greater tendency for the samples to vibrate.

[3] An Apparatus for Measuring the Relative Wear of Sole Leathers, B. S. Tech. Paper No. 147.

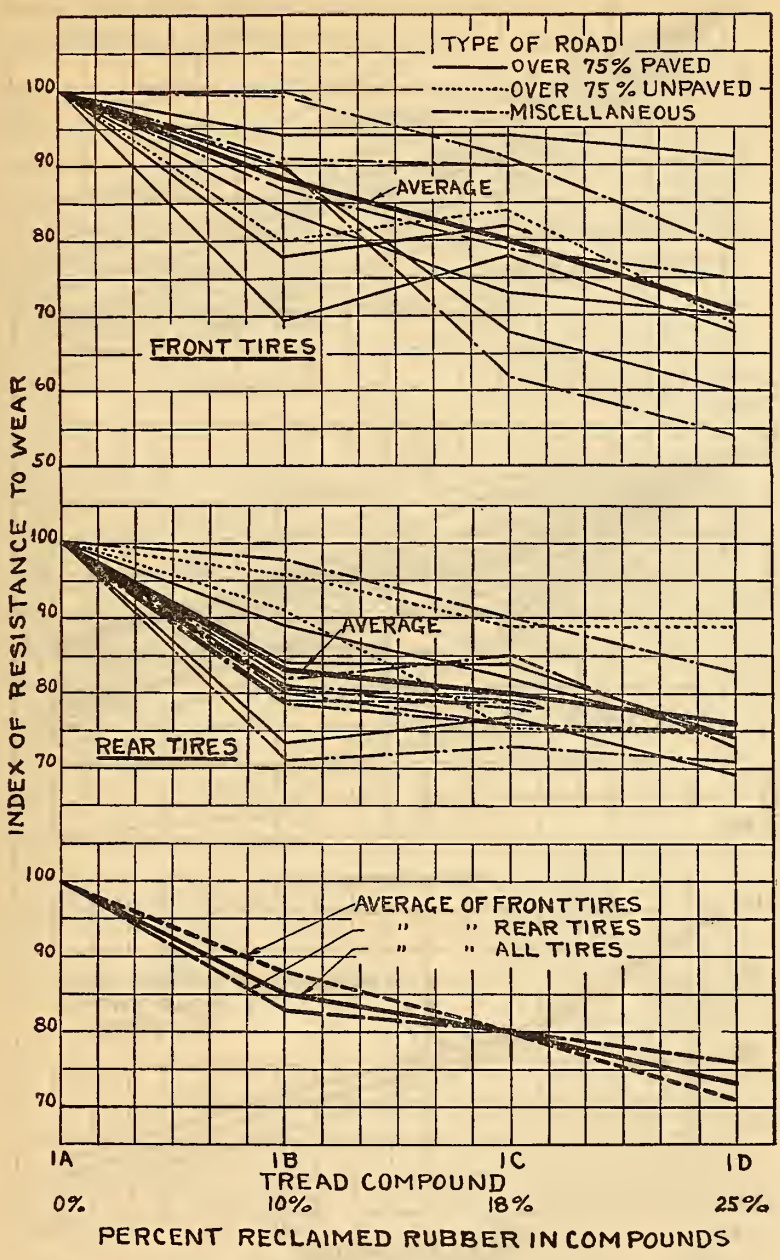

FIG. 2.—*Results of tread wear on No. 1 tires*

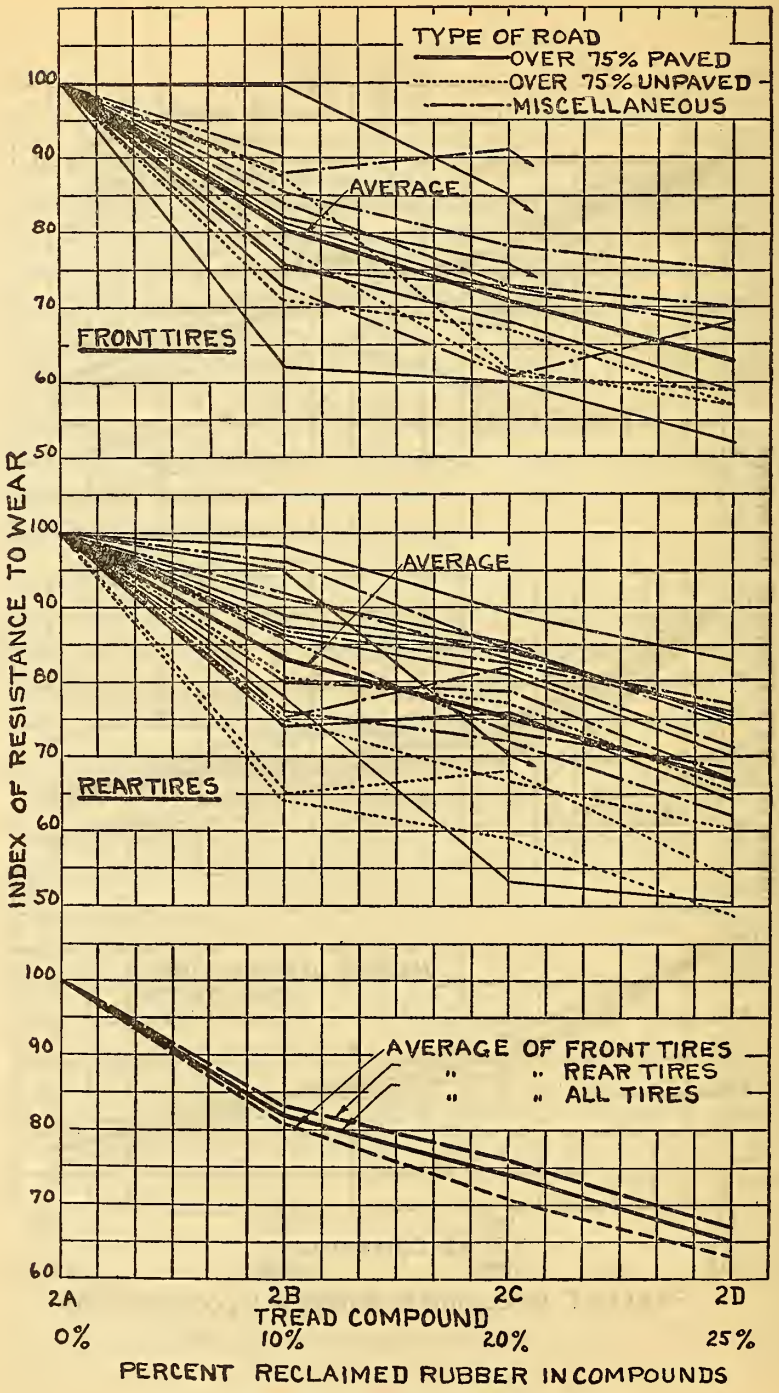

FIG. 3.—*Results of tread wear on No. 2 tires*

mately 15 inches in diameter. This wheel rests upon the surface of a carborundum disk whose axis is at right angles to that of the wheel, and thus the wheel and disk constitute a friction drive by means of which the samples drive the abrasive disk.

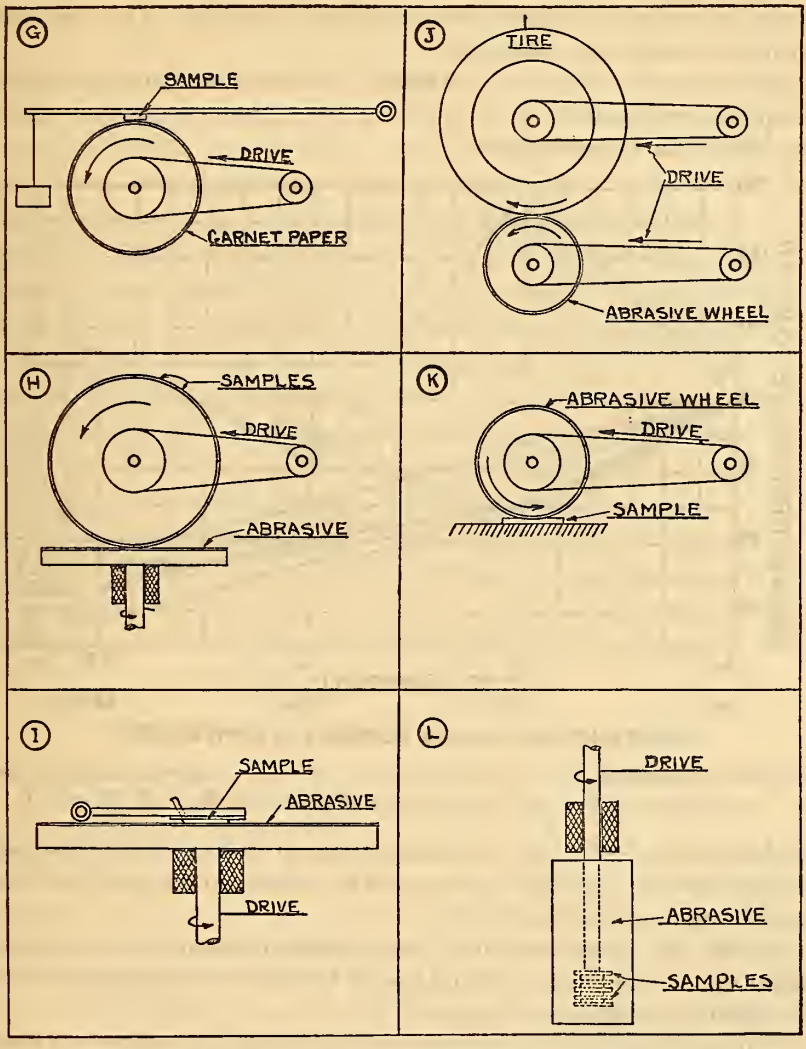

FIG. 4.—*Methods of operation of laboratory wear test machines*

MACHINE I.[4]—This machine consists essentially of a revolving table 30 inches in diameter, the surface of which is composed of crushed feldspar held in place with Portland cement. The samples 2 by 5 inches by ¼ inch are held in grips which are swivelled so that

[4] An abrasion machine issued by New Jersey Zinc Co., Feb. 1, 1923.

they move up and down under their weight. The samples bear against the surface of the table and are abraded as the table revolves.

MACHINE J.—In this test a complete tire is used. It is mounted on a rim, inflated, and pressed against the face of a carborundum wheel. The tire and the abrasive wheel are driven in the same direction where in contact, but at different speeds. The tire is run until the tread wears through.

MACHINE K.—This is a "straight" abrasion machine in which a sample approximately 2 by 3 inches by ¼ inch is pressed against the face of an abrasive wheel.

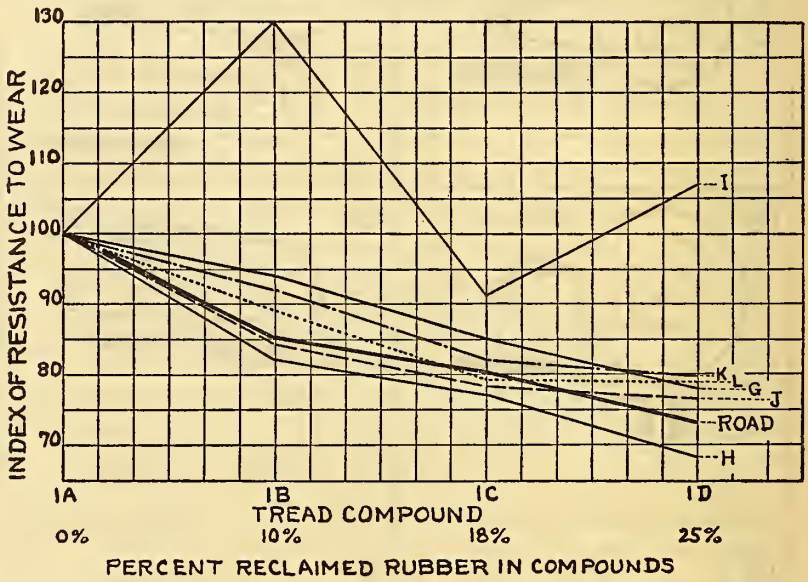

FIG. 5.—*Comparison of the resistance to wear of No. 1 tread compounds as determined by road tests and by laboratory machines G, H, I, J, K, and L*

MACHINE L.[5]—In this machine a series of disks of the rubber samples are held on a spindle and caused to revolve in a cylindrical vessel containing a granular abrasive.

In the case of all machines the indexes of resistance to wear are based upon the relative volume loss of the different compounds under the specific conditions of the test.

The results of laboratory tests on these various machines are shown in Figures 5 and 6. The comparison is made on the same basis as that of the road tests; that is, the index of resistance to wear as calculated for each compound is based on a value of 100 for the "A" compounds as an arbitrary standard.

It will be noted that except for machine I, the results of laboratory tests agree, in general, with the average road results.

[5] W. W. Evans, Proceedings A. S. T. M.; 1923.

It is not clear why there should be such a decided difference in the results obtained with machine I. The inconsistencies in its action on No. 1 and No. 2 compounds, as well as the general conclusion that it does not wear the rubber samples in the same manner as the other machines, were verified by repeated tests.

Based on the results of tests on these particular compounds, which are quite similar in general characteristics, it appears that any one of the machines with the exception of "I" might be chosen as a standard for laboratory use.

In carrying the work a little further, however, and dropping for the moment any relation between laboratory and road tests it be-

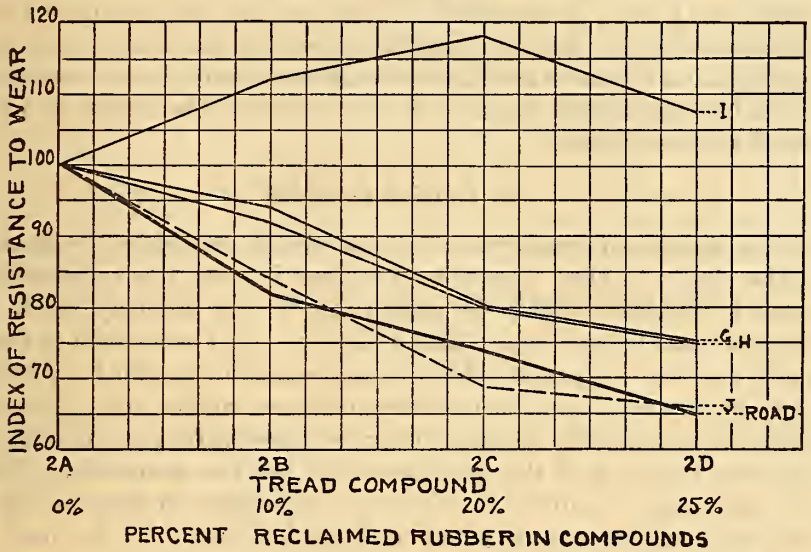

FIG. 6.—*Comparison of the resistance to wear of No. 2 tread compounds as determined by road tests and by laboratory machines G, H, I, and J*

came evident that unless caution is exercised in conducting and in interpreting the results of laboratory tests, erroneous conclusions may be reached. Two points in particular were noted. The first is that with some machines the state of cure of the test samples influences the results greatly while with others it has very little effect. The second feature which was observed is that in comparing different types of compounds, variations in the indicated resistances to wear are in some cases obtained which are not in accord with known characteristics. While complete data covering these points are not available, some general observations were made on machines G, H, and I. In regard to the influence of the state of cure on the indicated resistance to wear, it was noted that machine I is very sensitive to any change in cure, while with machines G and H the cure has a comparatively small influence. Thus it is obvious that in making

laboratory wear tests the question of the state of cure of samples should be given careful consideration.

In regard to the comparison of different types of compounds, such as a rubber composition sole with a tread stock, machine G indicates that, with respect to the resistance to wear, the tread stock is somewhat superior; machine H, that the tread stock is much superior; while machine I indicates that the composition sole is superior. This, of course, is rather an extreme case, but nevertheless shows some of the limitations of wear tests and the caution which must be exercised in their interpretation. The fact that machine I is much more sensitive to cure and that it gives quite different results than machines G and H means that it is able to pick out certain physical characteristics of rubber compounds which the others can not. Reference to Figures 5 and 6, however, show clearly that the property of rubber compounds which it does show is not the ability to withstand tire tread wear.

V. CONCLUSIONS

The results of road tests on tire treads containing reclaimed rubber indicate that if reclaimed rubber is used the resistance to wear is lowered roughly in proportion to the quantity used. A reference to Figures 5 and 6 shows, however, that even when as much as 25 per cent reclaimed rubber is used a tread can still be made at least 70 per cent as good as one containing new rubber only. Accordingly the advisability of substituting reclaimed rubber for new rubber becomes a matter of the relative cost of the two materials. There are also many products in which the resistance to wear is not of first importance and in which reclaimed rubber may be used as satisfactorily as new rubber.

Although as a matter of common observation the wear on the rear tires is usually greater than on the front tires, the relative wear of the tread compounds is practically the same for either front or rear tires.

The data obtained on the influence of the type of road on wear of tire treads indicate that the same relative differences in tread wear will show up on different types of roads.

The laboratory test machines used in these experiments for measuring the resistance to wear of tire tread compounds give results in a large proportion of the tests which are in close agreement with service tests.

Washington, May 25, 1925.